Hangman Creek Total Phosphorus Loading Estimates

by Joe Joy

Monthly average phosphorus load estimates can be calculated in several ways. The type of data available determines the most appropriate methods. Every technique uses the available data to interpolate what loads are present when samples are not taken, and each resulting estimate has bias and imprecision. Several methods are available that use continuous discharge data with constituent samples that are taken at less frequent intervals.

Ecology used a multiple regression equation with seasonal adjustment and bias-correction factors (Cohn, 1988) for a preliminary total phosphorus (TP) loading analysis during the Hangman Creek TMDL evaluation. The multiple regression technique was used because Hangman Creek TP concentrations generated from Ecology monthly monitoring data are correlated with discharge volumes (Figure 1), and have a seasonal component. Multiple regression load evaluations have been successfully used by USGS and many researchers to estimate sediment, nutrient, and other water quality constituent loads for monthly, quarterly, and annual intervals when continuous flow data and infrequent constituent samples are available. It is considered to be less biased and more precise than simple averaging techniques.

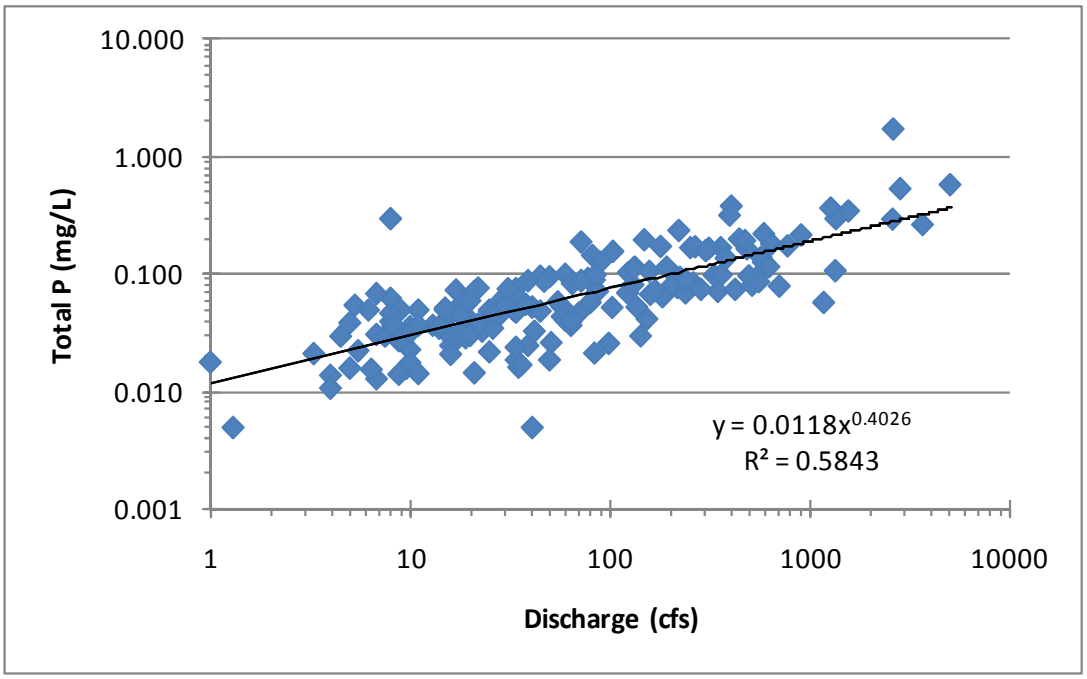

Figure 1. Total phosphorus (Total P) concentrations and associated daily flows at the mouth of Hangman Creek collected from 1989 to 2005 (Ecology 56A070).

Total phosphorus load estimates based on two months of Hangman Creek TP and discharge monitoring data are compared to the multiple regression technique results in the following example. The first three columns in Table 1 show the dates of collection, TP concentrations reported by Ecology, and the daily average USGS flows for those dates at the mouth of Hangman Creek in March and April of 2001. The estimated TP loads using those data are shown in the fourth column. The values were used by HDR

Engineering (2009) as average monthly TP load estimates in their Spokane River and Hangman Creek TP load evaluation (see Figure 3.7 in their report).

Table 1. Total phosphorus load estimates based on data from the mouth of Hangman Creek in March and April 2001. Load estimates from observed data and a multiple regression equation are shown.

	USGS Daily Discharge	Total Phosphorus	Estimated Daily Load	Multiple Regression Daily Load	USGS April and May 2001 Mean Monthly Discharge	Multiple Regression Average Monthly Load
Date	cfs	mg/L	lbs/day	lbs/day	cfs	lbs/day
3/12/2001	476	0.195	501	409	329	255
4/9/2001	267	0.085	122	137	210	97

The fifth column is the estimated daily TP load for those two days based on the multiple regression equation. The estimated loads for the two days are different from the observed loads, but an analysis comparing all observed and regression results from 1989 to 2005 gave a Nash-Sutcliffe coefficient of 0.95. This means the multiple regression loads have low bias and a high correlation with observed loads. Ecology then used all daily regression load estimates in the month to estimate the mean monthly loads shown in column seven. USGS mean monthly discharges for March and April 2001 are shown in column six. All of these data are illustrated in Figure 2 along with USGS mean daily discharge data (labeled Discharge) and daily multiple regression TP load estimates (labeled Daily load estimate).

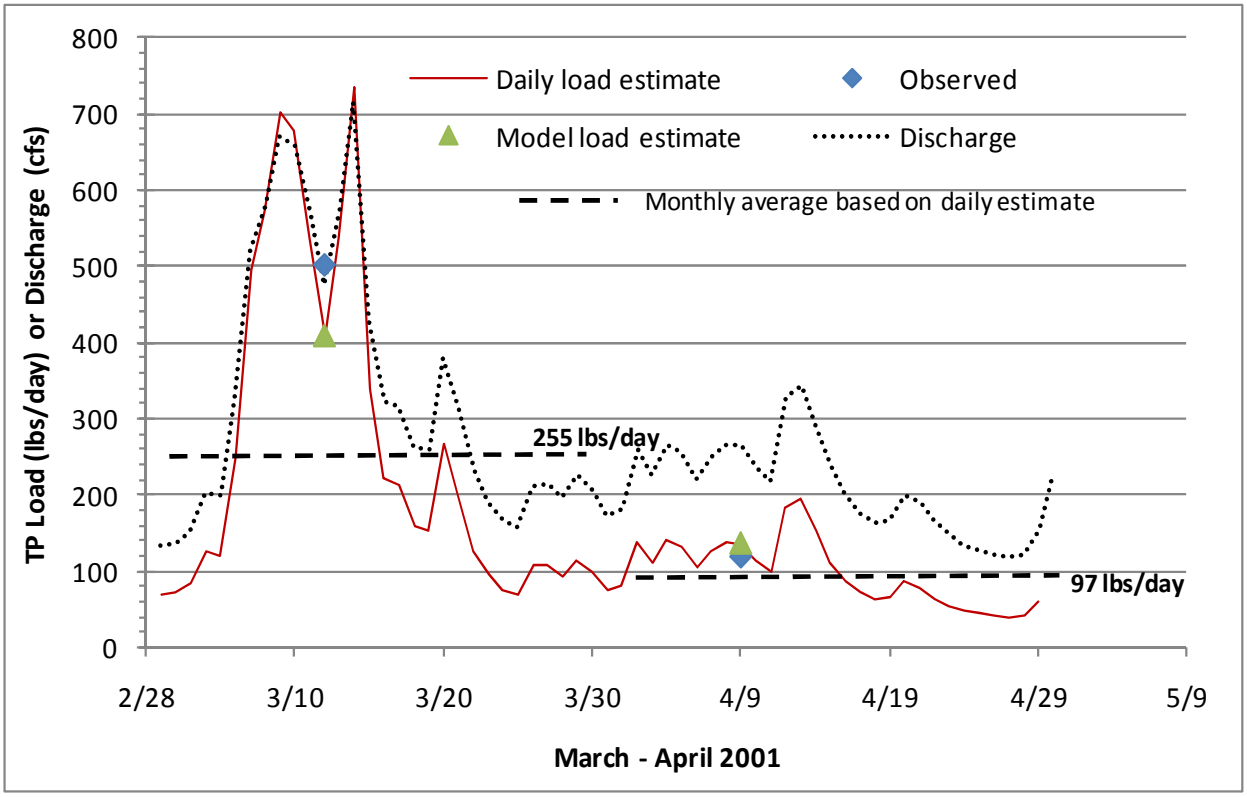

Figure 2. USGS daily discharge data and estimated total phosphorus (TP) loads based on observed total phosphorus concentrations and multiple regression equation generated estimates.

The example using these two months demonstrates how different or similar the single observed load estimate can be from loads estimated using the multiple regression results. The TP monthly average load using the regression equation for March (255 lbs/day) is much less than the sampled load (501 lbs/day) because the last half of the month reported declining flows, and therefore, declining estimated daily TP loads. The April sampled TP load (122 lbs/day) is very similar to the regression average load (97 lbs/day) because flows and estimated daily loads did not vary as much.

In conclusion, Ecology estimates of average monthly total phosphorus loads from Hangman Creek are probably more statistically precise than average monthly loads calculated from one or two monthly samples. Hangman Creek daily flows and resultant constituent loads are highly variable, especially during the winter and early spring. A calculated load from a single sample collection could be much higher or lower than the true monthly average load. The high variability is an important consideration in determining both the load reductions needed to protect water quality and for evaluating efforts to reduce loads in the future.

References cited:

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